APPENDIX 5-3

PMP/PMF MODEL DOCUMENTATION
TECHNICAL MEMORANDUM

BLACK & VEATCH

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South Florida Water Management District
EAA Reservoir A-1
Work Order No. 5

B&V Project No. 141522.0341
B&V File:C-1.3
First Issue: July 11, 2005
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Task 5.3.4.8.2 PMP/PMF Model Documentation Memorandum

Model Documentation of HEC-RAS, HEC-HMS, and HMR-52

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Model Documentation of HEC-RAS, HEC-HMS, and HMR-52

To: Shawn Waldeck & Rich Bartlett

From: Jim Schlaman, Karen Burgi, Sergio Ramos and Heather Kobach

1. OBJECTIVE

This memorandum documents the type, applicability, and results from the three models that determine the probable maximum precipitation (PMP) (HMR52), probable maximum flood (PMF) (HEC-HMS), and dam breach characteristics (HEC-RAS) for the design criteria of the Everglades Agricultural Area (EAA) Reservoir A-1. All three models were developed by the Hydrologic Engineering Center (HEC) of the US Army Corps of Engineers (USACE).

2. HRM52 (PMP MODEL)

HMR52 is a computer program designed to simplify and automate many of the calculations detailed in Hydrometeorological Reports 51 and 52, required to determine the PMP (NOAA, 1978 & 1982).

2.1 Model Description and Applicability

Hydrometeorological Report (HMR) Nos. 51 and 52 were developed to analyze data and provide logic and methodology for predicting the PMP east of the 105th Meridian, including the Everglades. The computer program HMR52 was developed to automate the calculations needed to follow the procedures in HMR No. 52. HMR No. 52 recommends a procedure for estimating the PMP to an area that requires both a temporal and spatial distribution of the precipitation

HMR52 computes basin-average precipitation for PMP and takes into account geographical location, geometry of the study area, orientation of the study area, and depth-area-duration rainfall data from HMR No. 51.

2.2 Model Input and Assumptions

For additional information on the theory and methodology of forecasting PMP, use HMR Nos. 51 and 52. Appendix 5-4 includes the HMR52 User's Manual (USACE, 1984) and Installation information. The HMR input files for the various EAA model runs are included in Appendix 5-5.

2.2.1 Study Area and Location

The actual coordinates describing the study area boundaries were used for PMP modeling. Although HMR52 will automatically calculate the center of the storm given the study area boundaries, on some of the runs a study area center was manually identified. In addition, real latitude and longitude of the study area is required to determine the Depth-Area-Duration values discussed in the following section.

2.2.2 Depth-Area-Duration

In HMR No. 51, historical data was manipulated to generate theoretical maximum storms for nonorographic (non-mountainous) regions. This included maximizing the available atmospheric moisture, transposing historical storms to other areas of interest, and constructing smooth isolines across the eastern United States to cover data gaps. The result is a series of PMP maps for drainages between 10 and 20,000 mi^2 and for durations from 6 to 72 hours. These depth-area-duration numbers are then used in the model to determine the incremental change in rainfall amount. The depth-area-duration values used for this model, based on the location (latitude and longitude) of EAA Reservoir A-1 are shown in Table 1.

2.2.3 Spatial Distribution

The probable maximum storm (PMS) is represented by elliptical isohyets (lines with the same rainfall intensity), each of which has a ratio of major axis to minor axis of 2.5 to 1. It is assumed that the greatest volume of rainfall occurs when the isohyets are centered on the study area and oriented similarly. HMR No. 52 developed a preferred orientation for storms based on geographical location (Figure 8, USACE, 1984). The orientation is related to the general movement of storm systems and the direction of moisture-bearing winds. For basin orientations within 40 degrees of the preferred orientation, 195 degrees for Reservoir A-1, the full PMP is used. For basins with orientations more than ±40 degrees off the preferred orientation, and at least 300 mi^2 in area, an adjustment factor should be used. The orientation must be between 135 and 315 degrees from north.

2.2.4 Temporal Distribution

The model assumes that the PMP for all durations (up to 72 hours) occurs in the same PMS. It was further assumed that the 6-hour period with the greatest precipitation occurred in the seventh, 6-hour period. In order of decreasing magnitude, the remaining eleven, 6-hour periods were arranged before an after the peak 6-hour period (i.e.: 12, 10, 8, 6, 4, 2, 1, 3, 5, 7, 9, and 11).

2.2.5 Reservoir Inflow Hydrograph

Utilizing the HMR-52 program and calculated PMP distribution, an inflow hydrograph for the EAA Reservoir A-1 was calculated. The specific hydrographs are detailed in the are detailed in Appendix 5-7.

2.3 Model Output and Results

The model output files are included in Appendix 5-6. The model output includes the following information:

- The study area and centroid coordinates.

- Calculated storm area maximizing PMP.
- Calculated orientation maximizing PMP.
- Depth vs. Duration by isohyet for 6-hr increments.
- Storm hydrograph. Incremental and total rainfall by 10-minute interval.

2.4 Post-Processing

The results of the storm hydrograph were combined with the EAA Reservoir A-1 area to generate an inflow hydrograph for EAA Reservoir A-1. These results are included in Appendix 5-7. Electronic copies of the HMR52 program and input/output model files are in Appendix 5-12.

3. HEC-HMS (RUN-OFF MODEL)

3.1 Model Description and Applicability

The PMP/PMF hydrologic model was created using the US Army Corps of Engineer's Hydrologic Modeling System (HEC-HMS). This model was designed to simulate the precipitation-runoff processes of watersheds. It is capable of modeling a wide range of geographic areas. The program can accurately depict the water supply of a large river basin, hydrology (including flooding conditions), as well as small urban or natural watershed runoff. The hydrographs produced by the model can be used in a number of ways. One of which is to help determine reservoir spillway design and compliancy of floodplain regulations. The model's graphical user interface facilitates the schematic model design, making the model very user friendly.

3.2 Model Input, Assumptions and Output

A complete list of output parameters may be referenced in the HEC-HMS Users Manual shown in Appendix 5-8. Model Input and Outputs are summarized in Appendix 5-9. A copy of the HEC-HMS program and input/output files are included in Appendix 5-12.

4. HEC-RAS DAM BREACH MODEL

4.1 Model Description and Applicability

The USACE Hydrologic Engineering Centers River Analysis System (HEC-RAS 3.1.3) computer model allows hydraulic computations to be performed on one-dimensional systems for both steady and unsteady flow simulations. A dam breach event is an unsteady flow event in which a dam fails and the reservoir stored behind the embankment rushes out through the breach. HEC-RAS 3.1.3 is capable of modeling a breach event utilizing the unsteady flow Saint-Venant equations. HEC-RAS's solution technique is similar to the 1980 National Weather Service DAMBRK model and produces comparable results.

The hydraulic calculations for cross-sections, bridges, culverts, and other hydraulic structures were incorporated into the unsteady flow module. The unsteady flow component has the ability to model storage areas and hydraulic connections between storage areas, as well as between stream reaches. The HEC-RAS unsteady flow model allows breach parameters such as breach

width, full formation time and breach location to be input. At a specified time or water surface elevation, the model begins breaching the specified internal structure to simulate its failure.

4.2 Model Input, Assumptions and Output

A complete list of output parameters may be referenced in the HEC-RAS Users Manual shown in Appendix 5-10. Model Input and Outputs are summarized in Appendix 5-11. A copy of the HEC-RAS program and input/output files are included in Appendix 5-12.

TABLE

Table 1 Depth-Area-Duration for EAA Region

Area (mi^2)	Duration (hrs)				
	6	**12**	**24**	**48**	**72**
10	32.0	38.7	47.1	51.8	55.7
200	24.6	31.2	39.5	44.3	48.8
1,000	18.2	24.9	33.2	27.7	41.3
5,000	10.1	15.0	21.9	26.6	30.7
10,000	7.6	11.8	17.6	22.5	26.5
20,000	5.6	9.2	13.6	18.0	22.0
Note: HMR No. 51 (NOAA, 1978) indicates that for areas of Florida south of the last PMP isoline, which includes the Everglades, the PMP values for the southernmost isolines should be used.					